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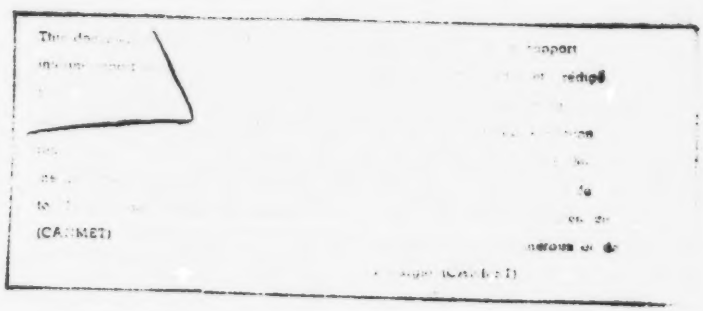
IRON ORE MINING IN ERZBERG, AUSTRIA

V. Srajer

December 1987



MICROMEDIA

ENERGY RESEARCH PROGRAM
COAL RESEARCH LABORATORIES
DIVISION REPORT CRL 87-138(TR)

88-03383/

IRON ORE MINING IN ERZBERG, AUSTRIA

by

V. SRAJER*.

ABSTRACT

The iron ore mine Steirische Erzberg, located in the Styrian Ore Mountains in Austria, was visited in October 1987. The purpose of the visit was to familiarize the author with the mining method used, transportation problems associated with ore and waste removal at mountain deposits and to discuss new technological developments proposed for the mine.

In this report the geology and history of the deposit, one of the oldest in Europe, is described, together with the mining methods practiced. In addition ore preparation, beneficiation and separation is explained.

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EXPLOITATION DU MINERAI DE FER À ERZBERG, EN AUTRICHE

par

V. Srager*

RÉSUMÉ

En octobre 1987, nous avons visité la mine métallique de fer Steirische Erzberg, située dans les montagnes de minerai de la Styrie, en Autriche. Nous désirions nous familisariser avec les méthodes d'extraction et les problèmes de transport liés à l'enlèvement du minerai et des déchets des gisements situés en montagne, et étudier les nouvelles techniques qui doivent être utilisées à la mine.

Le rapport fait état de la géologie et de l'histoire du gîte, l'un des plus anciens en Europe, et des méthodes d'exploitation utilisées à cet endroit. Les techniques de préparation, d'enrichissement et de séparation du minerai sont également expliquées.

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INTRODUCTION

The Styrian Ore Mountain (Steirische Erzberg) mine can be reached by travelling approximately 150 km south of Vienna on Highway 17 and taking Highway 113 west at the Kapfenberg turnout for about 60 km past the town of Leoben, where the road ends in the town of Eisenerz, located at the foot of the Styrian Ore Mountain mine.

From the centre of the basin of the rivers Muerz and Mur, surrounded by 2000 m high mountain massif, rises the nearly 1500 m high Ore Mountain, being about 800 m above the valley floor. Towards the south the Erzberg is linked to the 2166 m high Mount Reichenstein by a narrow ridge, so called 'Platte', nearly 1370 m above sea level.

The town of Eisenerz lies at the northern foot of the Erzberg. The town history and development is closely linked to the mining of the ore deposit. The town was established as a 'market town' and granted the corresponding privileges in the beginning of 13th century.

The location of the mine is apparent from Figure 1.

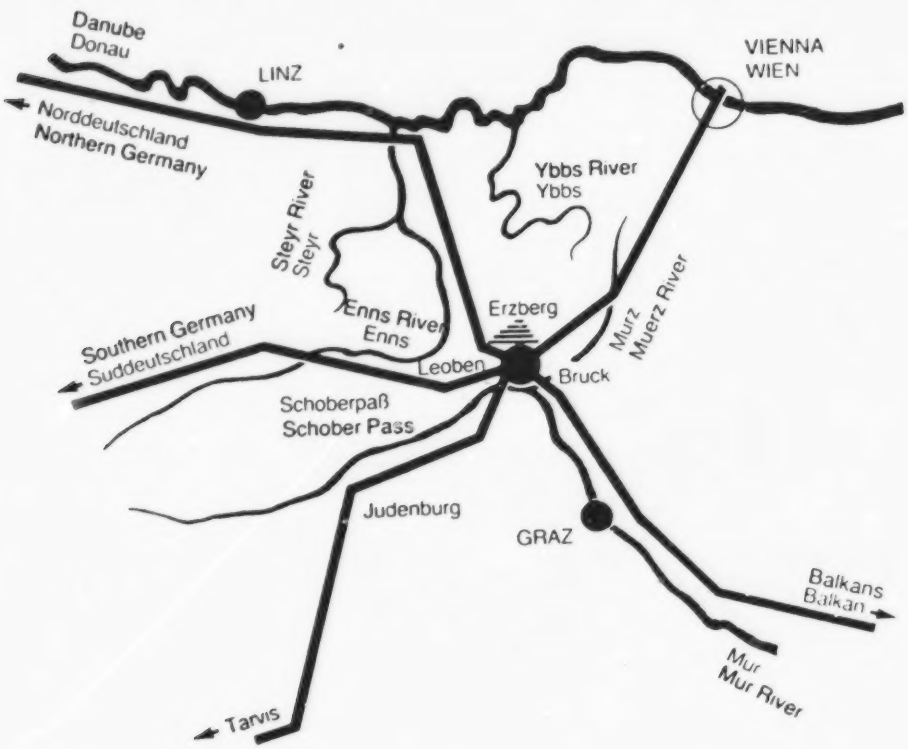


Figure 1 Location of the Steirische Erzberg.

HISTORY

Iron ore has been smelted in the area since the 3rd century A.D.. First settlement by Slavs and subsequent colonization by Germanic tribes is documented in the year 712. During the Middle Ages the lower part of the Erzberg was being mined. At that time there were smelters located at the sides of creeks and rivers flowing through the valley. In the 14th century iron ore was shipped via the iron trading places Leoben and Steyr to all parts of Europe. By the year 1294 the settlements in Eisenerz were raised to the level of marked town and 'Iron Ordinance' was granted. By the year 1581 ore extraction was shifted to underground mining, because of the depletion of the limonite layers and lenses near the surface.

In 1625 the private mines were combined to form company called Innerberger Hauptgewerkschaft, having all miners organized into a privilleged 'guild'. By the year 1806 the combined production from the area was 5.5 tons of hot metal per day. A railway was introduced to the region in 1817, the oldest in Austria. In 1868 the smelters were nationalized and formed a state mining enterprise called Montan Aerar. The mines were allowed to remain in private hands.

Surface mining commenced in the mid 1800's, dynamite blasting was introduced in 1870 for the first time. Steam locomotives were introduced in 1878.

In 1881 the Innerberger Hauptgewerkschaft was renamed Oesterreichisch-Alpine Montangesellschaft. The company introduced electric locomotives for the mine and before the turn of the century freight hauling using cog-wheel railway line was in place. This company also commenced planned surface mining of the entire mining area that resulted in 60 benches, each of them about 12 m high. The underground mining was totally abandoned. In 1910 steam shovel mining (bucket capacity of 2 m^3) and machine drilling was introduced. Electric shovels of 2.25 m^3 bucket size were introduced in 1928. During the second world war, the mine was expanded and mechanized, underground mining resumed again, new smelting facilities and shops build. The production reached almost 14 million tons per year (combined ore and waste). After the war, the operation stopped completely and smelters were dismantled and scrapped.

In 1950 operations started again, with the aid of European Recovery Program (ERP) funds. Rail-less power shovels and heavy-duty trucks were introduced and a new crusher, heavy-media separation and benefication plants were built. In 1962 the production of iron ore reached 3.3 million tons. In 1973 the new state owned company Voest-Alpine took over operation. A modernization program commenced in 1982. Study is underway at present to introduce 77 tonnes trucks, front-end wheel loaders and shovels of payload capacity of 9.6 m^3, central dumping and loading facilities and rail or conveyor transport system. Mine operation is centrally computerized, using truck allocation dispatch facilities, ore blending and equipment allocation planning software, and maintenance control programs.

GEOLOGY

The Steirische Erzberg is part of the paleozoic zone, which extends east to west between the mesozoic Northern Alps and Central Alps, from the Province of Lower Austria to the Tyrol.

The footwall contains metamorphically transformed quartz of Ordovican age with interlacings of clay, silica, graphite, and shale. The ore body consists of Silurian and Devonian limestones, tectonically structured into a lower strata of the ore body, containing more calcareous shale, and upper strata, composed of reef limestones, separated by layers of shale of the Lower Carbon period. The hanging wall consists of shales and limestones with gypsum enclosures as well as the limestone breccia. The Calcareous formations transformed by the action of hot water containing iron, magnesium and manganese, led to a conversion of limestones into the siderite, ankerite and feric dolomite. As a result of the oxidation process, the siderite and ankerite have been partially converted into the limonite with manganese encrustations. The mineralization of the large areas occurs both in the bottom, as well as in the top layer of the bed, taking the form of the two seam-like zones.

The topography of the Erzberg mine area is shown in Figure 2, a vertical cross section of the mine in Figure 3.

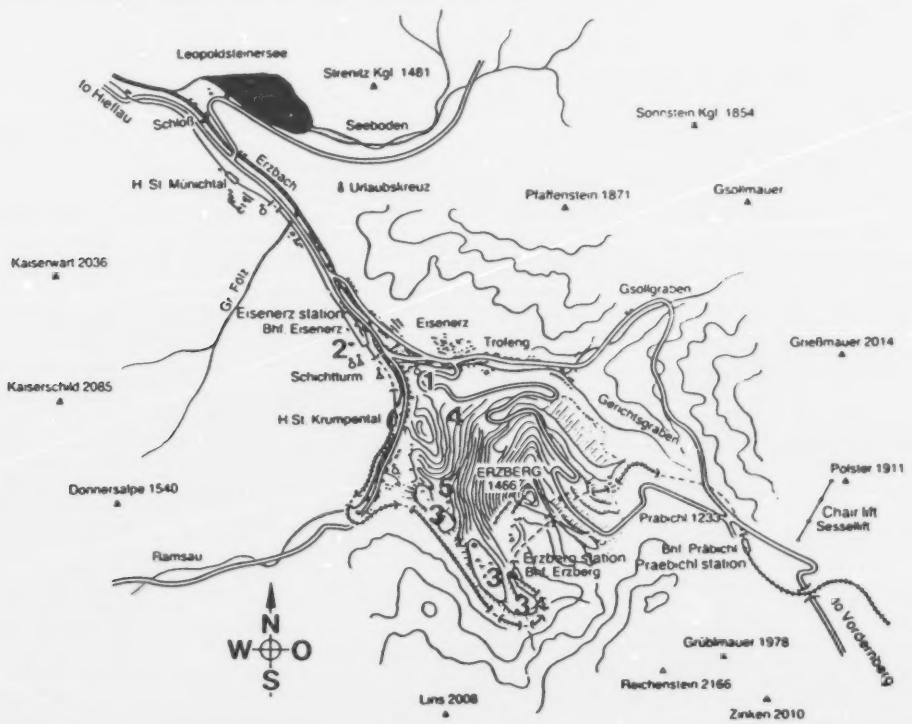


Figure 2 Topography of the Erzberg's Area.

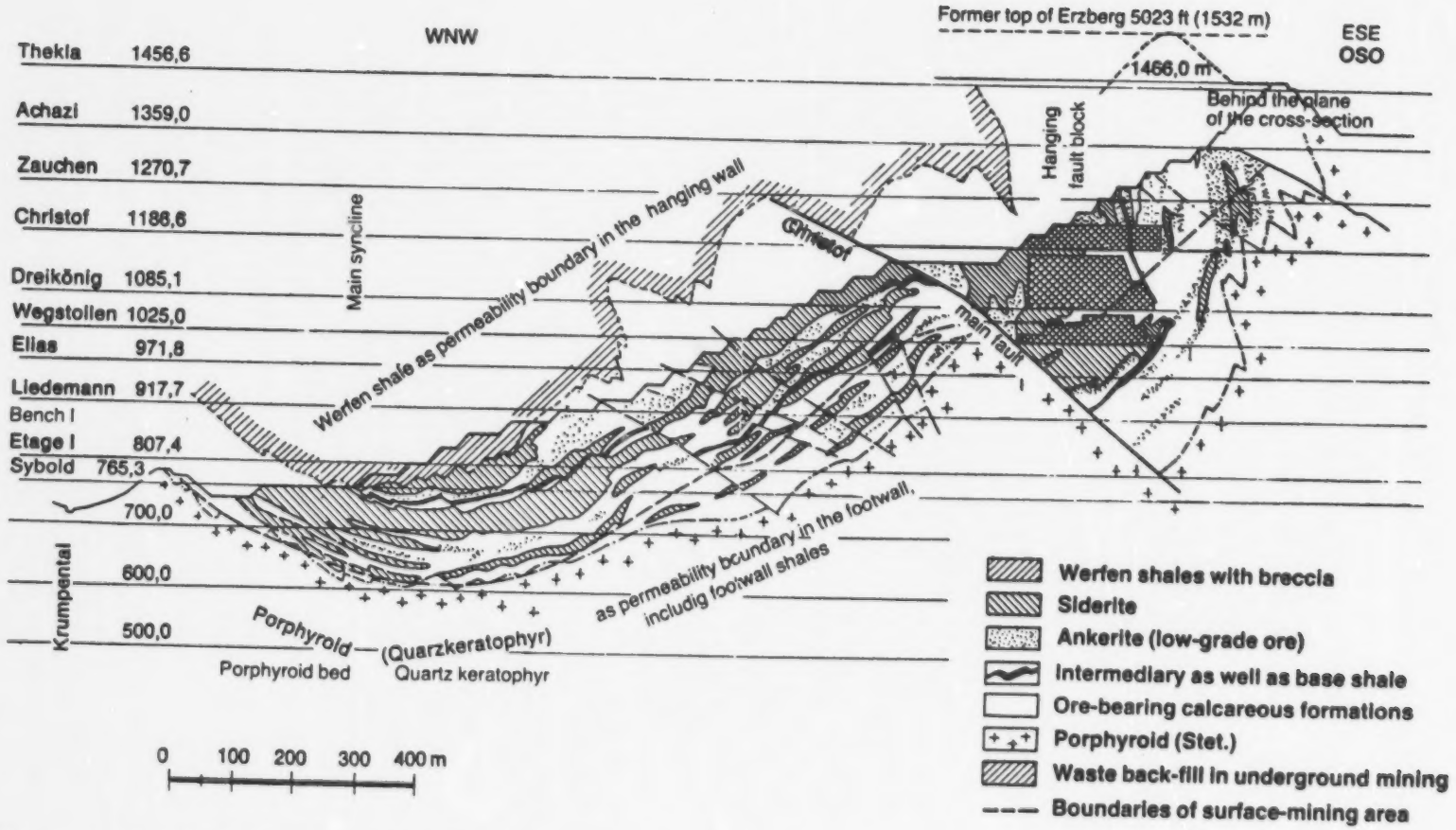


Figure 3 Vertical Cross Section of the Mine

The total ore reserves (proved and probable category) are approximately 176 Mt. Since the deposits do not contain siderite only, but also large quantities of an ankerite and gangue, the amount of ore currently obtained comes to about one fifth of the broken material. About 60 percent of marketable ore are obtained by benefication, while 40 percent is made up of a direct-shipping ore. This ore consists of a mixture of two parts (by volume) of siderite with an Fe content of about 40 percent, and one part of ankerite, having average Fe content of 15 percent. The overall averages of content are: 32-34 percent Fe, up to 2 percent of manganese, traces of sulphur and phosphorus.

MINING METHODS

Underground Mining

Approximately 7 percent of the total material mined, and about 21 percent of the total ore production come from the underground mining. Shafts are sunk primarily in zones rich in ore, outside the regular surface mine boundaries. The room and pillar mining method with cut and fill is used. The front-end loaders with a bucket payload capacity of 3.8 m^3 are employed in the loading operation. The Joy loaders and shuttle cars are used to transport ore in the galleries. The waste material from the surface and tailings is used for the backfilling.

The ore body is first opened from the central gallery, slanting along with the incline of the ore body, at distances of over 11 m to the foot wall as well as to the hanging wall of the ore body. In the backfilled horizon above, stowage galleries are then opened up. The individual stoping drifts are connected to the backfilled drifts by raises. The long drill holes are drilled from the openings above the actual stoping drifts. The mining will proceed after blast from the footwall and hanging walls towards the central gallery. Each chamber is eventually about 8 m wide, while the pillars are 3 m wide. Between one opening comprising of 4 to 5 slices, each 19 m wide, and a next opening, a pillar 8 m wide is left. The schematic of underground mining method is in Figure 4. A rig car with two booms is used for drilling in the underground mine.

The underground mine workings are ventilated by two fans, each rated at a 280 kW. Together they blow approximately 10,000 m^3 of fresh air per minute into the mine.

The mine rescue team is equipped with ambulance stationed directly at the mine entrance for fist aid and medical facilities at the town hospital, 2 km east of the mine entrance.

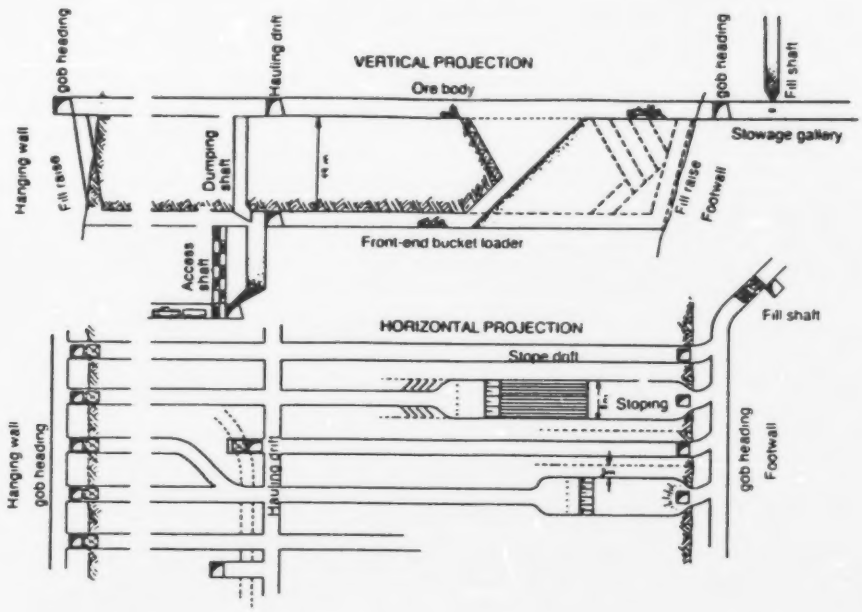


Figure 4 Schematic of Underground Mining

Surface Mining

Currently, strip mining involves 23 surface active benches with an average height of 24 m and an average length of more then 860 m each. Some of these benches have been divided into two 12 m high secondary benches. The upper benches of the mine have been completely mined. Work now progresses in the middle and lower benches. The lowest benches are established at about 740 m above sea level.

At present, three large power shovels with a bucket capacity of the 6.1 m^3 each, and five fron-end loaders with 9.6 m^3 buckets, are major loading equipment. The electric power shovels average about 520 tons per operating hour, the wheel loaders about 470 tons per operating hour.

The removal of blasted rock (ore and waste) is handled by the heavy duty trucks. Ore material is taken to processing facilities for separation, crushing and screening. Waste is transported to various dumps

around the pit area. Currently, 21 trucks are available for the surface mine: 14 have payload capacity of 77 tons, and 7 have 67 tons. The 77 tons model trucks handle an average of approximately 210 tons per operating hour.

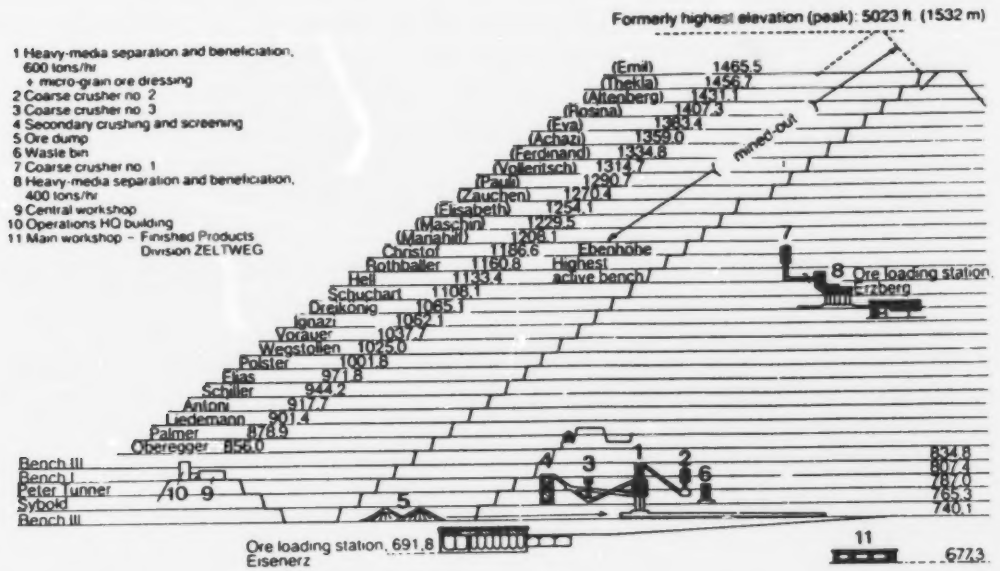


Figure 5 Schematic of Mining Terraces

The schematic of mining terraces of the mine, showing names of each bench, is illustrated in Figure 5. The following eight photos in Figures 6 to 13 were taken at the mine during the visit.

The rock is drilled using self propelled hydraulic drilling rigs, powered by a 430 HP diesel engine. The units are suitable for rotary drilling, using stepped bits, as well as for rotary percussive drilling with deep-hole hammers. The diameter of the bore holes varies from 150 to 160 mm. The mobile head-drilling cars for 85 mm drilling with deep-hole hammer and compressed air drive are also in use. For the floor drilling, a wheel loader frame has been equipped with a drilling boom. The rig accepts common drill hammers as well as deep hole hammers, and has its own compressor. The 85 mm drill units are used for the pre-splitting bore holes for final slope angles.

The holes are drilled 7 to 8 m from the edge, parallel to the wall, all the way down to the floor of the lower bench. Sometimes, toe holes are required in special operating conditions. They are drilled almost horizontally at the base of the bench.

Slurry explosives are used with instant, half-second and milisecond detonators. An average of 95 grams of explosives are needed for each tonne of the ore. A plant for the production of blasting slurries has been erected at the mine. A mixer truck is used for transportation and pumping of the

Figure 6 View of Upper Benches

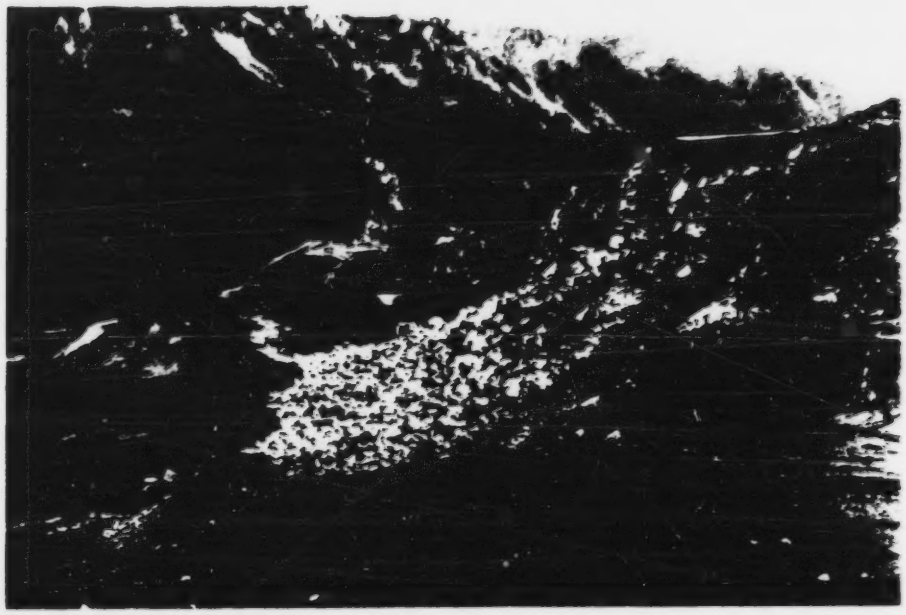


Figure 7 Blasting of Active Bench

Figure 8 West Waste Dump Area

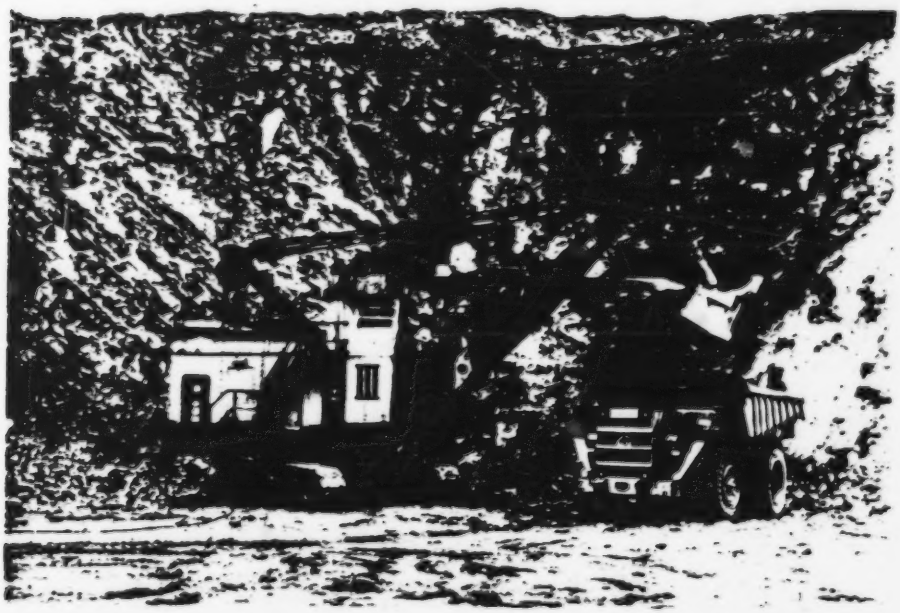


Figure 9 Loading of Waste Material

Figure 10 Large Hole Drilling

Figure 11 Toe Holes Drilling

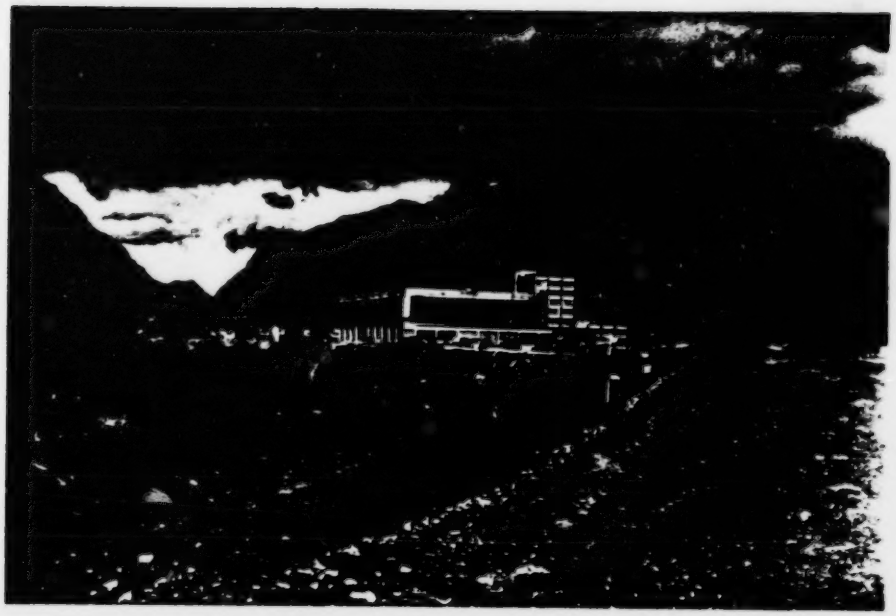


Figure 12 Maintenance Shops

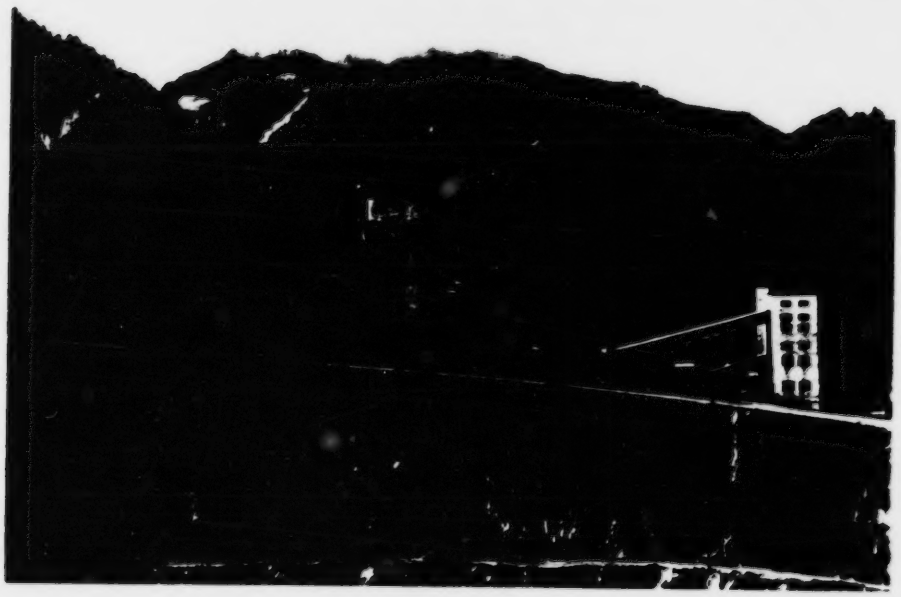


Figure 13 Ore Preparation Plant

slurries. A schematic of large hole drilling is shown in Figure 14. The large hole and toe drilling is also illustrated in Figures 11 and 12.

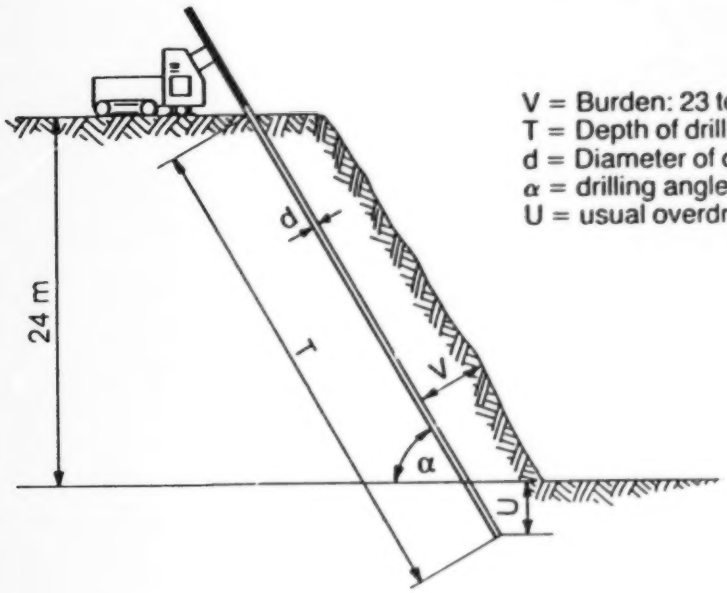

V = Burden: 23 to 26 1/3 ft
T = Depth of drill hole: 85 to 88 1/2 ft
d = Diameter of drill hole 5 to 5"
α = drilling angle: approx. 65°
U = usual overdrilling depth: approx. 5 ft
24 m
d
T
V
α
U

Figure 14 Section of Large Hole Drilling

ORE PREPARATION

The schematic of mining and processing is shown in Figure 15. Figure 16 illustrates the secondary crushing and screening schematic and Figure 17 the ore preparation plant schematic.

The preparation of ore material commences in a heavy media separation units, using the American WEMCO process, designed for rocks up to 100 mm in size. The material is taken by trucks to the gyratory crushers having capacity of 400 to 800 tons/hour, driven by a 190 kW motor. Then the material is taken to the heavy-media separation units and conveyed to the flushing screens, to be freed from clay and fine material by the flowing water.

The actual separation of ore and waste is performed in the slowly rotating separator drums, into which the heavy medium is infused. The composition and concentration of this medium is controlled by maintaining a specific gravity between 2.8 and 3.3. The ore, having specific gravity

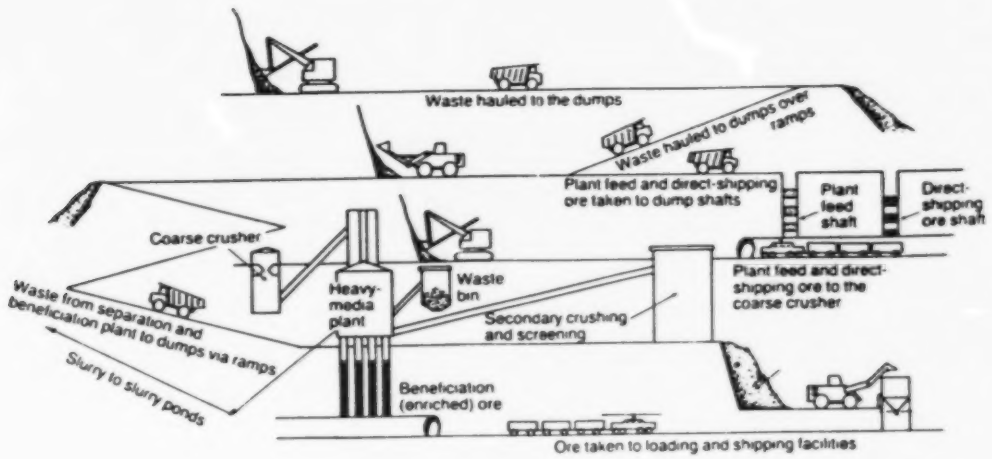
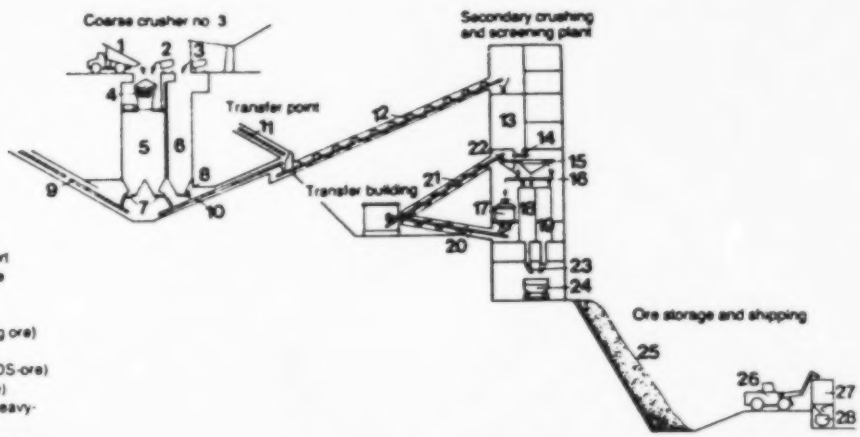
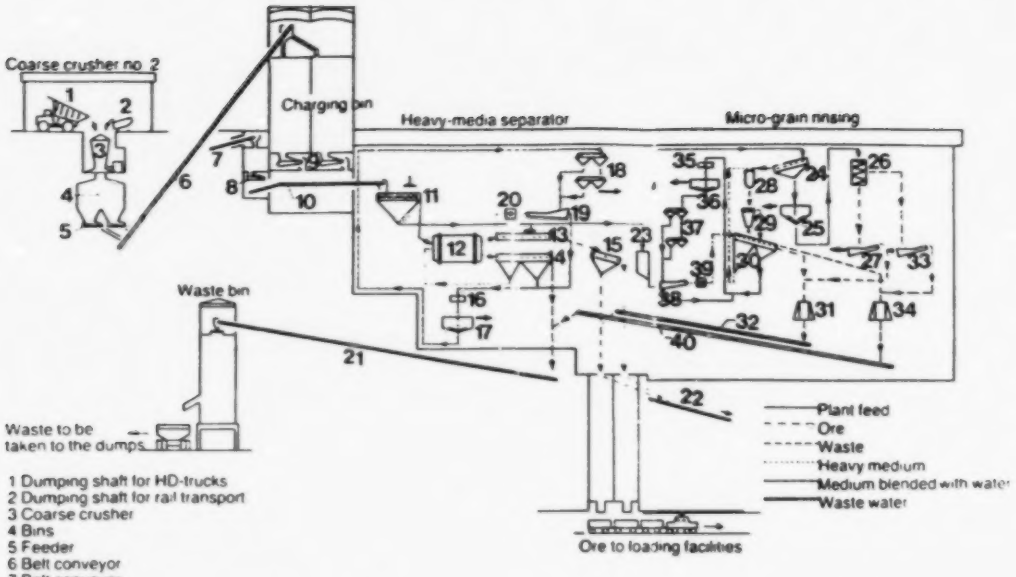

Waste hauled to the dumps
Waste hauled to dumps over ramps
Plant feed and direct-shipping ore taken to dump shafts
Plant feed shaft
Direct-shipping ore shaft
Coarse crusher
Heavy-media plant
Waste bin
Plant feed and direct-shipping ore to the coarse crusher
Waste from separation and beneficiation plant to dumps via ramps
Secondary crushing and screening
Slurry to slurry ponds
Beneficiation (enriched) ore
Ore taken to loading and shipping facilities

Figure 15 Schematic of Mining and Processing



1 Dumping point for HD-trucks
2 Dumping point for rail transport
3 Dumping point for concentrate Carried as rail freight
4 Coarse crusher
5 Bin (plant feed/direct-shipping ore)
6 Bin (concentrate)
7 Discharge chute (plant feed/DS-ore)
8 Discharge chute (concentrate)
9 Belt conveyor (plant feed to heavy-media separator)
10 Belt conveyor (direct-shipping ore to secondary crushing and screening
11 Belt conveyor (ore from the HMS)
12 Belt conveyor to SCS
13 Bin
14 Discharge chute
15 Classifying screen
16 Belt conveyor
17 Secondary crusher
18 Ore bins
19
20 Belt conveyor
21 Belt conveyor
22 Oversize screen
23 Loading of HD-trucks
24 HD-truck to ore dumps
25 Ore storage laps by front-end
26 Charging of bins by front-end wheel loaders
27 Ore bins
28 Ore to handling and loading for rail shipping

Figure 16 Schematic of Secondary Crushing and Screening



1 Dumping shaft for HD-trucks
2 Dumping shaft for rail transport
3 Coarse crusher
4 Bins
5 Feeder
6 Belt conveyor
7 Belt conveyor
8 Discharge gate
9 Discharge gate
10 Belt conveyor
11 Feed preperation screen
12 Separation drum
13 Drain and wash screen
14 Waste rock screen with rinsing facilities
15 Classifying screen - ore
16 Magnet coil
17 Medium thickener
18 Magnetic seperator
19 Screw classifier
20 Demagnetizing coil
21 Belt conveyor - waste
22 Belt conveyor - ore to SCP
23 Collecting bin
24 Classifying screen
25 Primary densifier
26 Humphrey spiral
27 Spiral classifier - ore
28 Mixing and blending vat
29 Hydrocyclone
30 Dripping and rinsing screen
31 Tumbling centrifuge - ore
32 Belt conveyor - ore
33 Spiral classifier - waste
34 Tumbling centrifuge - waste
35 Magnetizing coil
36 Fe-Si concentrator
37 Magnetic separator
38 Densifier
39 De-magnetizing coil
40 Belt conveyor - waste

Figure 17 Schematic of Ore Preparation

higher than the waste, precipitates and is then raised and taken to the ore channel by the compartments of the drum, while the much lighter waste is floated through the drum. After leaving the drum, both ore and waste are drained and screened, so that the ferrosilicon can be recovered as completely as possible on the dripping and washing screens. The ferrosilicon is then thickened at magnetic separators and fed back into the closed circuit. Finally, the ore is graded on the classifying screens, and taken to the storage bins. A Humphrey type spiral and hydrocyclone system has been also installed to extract ore fines of less than a 6 mm size.

The secondary crushing and screening plant consists mainly of a large crusher of the same type as the ones used in the heavy-media separators. There the ore is crushed to particle sizes below 100 mm in a single process. Belt conveyors take the crushed ore to the primary bins and the vibrating conveyors transport the ore onto double-decker screens, from where is transferred to an ore depot or a stockpile.

CONCLUSION

In this trip report, the mining methods, geology, mine history, and ore preparation, as practiced at the Steirische Erzberg mine in Austria are explained. Use of the mining equipment, underground and surface mining practices as well as drilling and blasting methods are explained.

The Erzberg mine is one of the largest surface mines in Europe. During the last five years, an average of 3.2 Mt of ore was extracted annually. The production of waste averaged 11.3 Mt, giving the overall waste to ore ratio of 3.5 : 1.

The mine is under reconstruction at present time. A study is under way to introduce a new transportation system and to improve productivity. New mine planning and scheduling software was installed at the mine office (French origin), the short and long-term planning is done now at the mine site. The mine work force is very immobile, being recruited from local population for generations. The mine management was quite conservative when a new technology was introduced in the past. Today's market pressure may bring some long delayed changes.

ACKNOWLEDGEMENT

The author acknowledge help of Mr. L.N. Decrinis, Commercial Officer of the Canadian Embassy in Vienna, Austria for arranging the mine visit, and Mr. V. Umfer of Voest-Alpine AG and Mr. P.K. Polak of the mine office in Eisenerz for their time given during the mine visit.

REFERENCE

"Steirische Erzberg", Voest-Alpine AG, Dep. R-K, GZW-Konzernwerbung, company information brochure (in German).